Ministry of Transportation
Ontario

MI-126

THE VARIABILITY OF PLATE AND CORED SAMPLES OF HOT MIX PAVEMENT TAKEN WITHIN TWO METRES

MATERIALS INFORMATION

ENGINEERING MATERIALS OFFICE

THE VARIABILITY OF PLATE AND CORED SAMPLES OF HOT MIX PAVEMENT TAKEN WITHIN TWO METERS

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ABSTRACT

In 1987, the Ontario Ministry of Transportation conducted a study to compare test results of plate samples taken at the time of placement, to three cored samples taken in close proximity after construction. The samples were tested for acceptance parameters; asphalt cement, + 4.75 mm and + 75 µm content.

This work was performed on five contracts and the results are contained herein. Tabulated data includes individual test results as well as summaries. Control charts for asphalt content and + 4.75 mm content are presented with both plate and core data points plotted. Scatter charts with asphalt content plotted against + 4.75 mm content including best fit line and correlation coefficient are contained.

Analysis of the data shows that 88% of the time the average values of the three cores support the determinations from the plate samples. However, individual core values can differ significantly from each other and from the plate sample.

Analysis of the control and scatter charts reveal:

1. a mix which has shifted from the design for both the asphalt and +4.75 mm sieve content,
2. a problem of the technician segregating the test portion of samples,
3. examples of mix segregation.

The views, opinions and conclusions expressed or implied in the text are those of the authors.

BACKGROUND

The Ministry of Transportation (Ontario) monitors the quality of hot mix pavement by obtaining a random sample from each 500 t of mix produced and testing it for asphalt content and gradation of the extracted aggregates.

The samples are obtained by placing a sheet steel template (plate) ahead of the paver, paving over it and then lifting out the plate with the hot mix on it. The sample is left on the plate and immediately transported to the acceptance laboratory usually located near the hot mix plant. At the laboratory, the technician removes the sample from the plate and through a process of mixing and quartering, reduces it to approximately a 1000 g test portion. The balance of the sample is packaged up for possible Marshall or monitor testing.

If the test results indicate that the material represented by the sample is rejectable, a coring programme is initiated to confirm the results and determine the limits of rejectable hot mix. (Table 1 contains the acceptance limits.) Ten cores are cut from between where the last non-rejectable sample was taken and the next non-rejectable sample or end of the work. The core locations are determined on a stratified random basis such that each core represents one tenth the area. Testing starts with the core located closest to where the rejectable sample was obtained and then progresses outward in both directions until two consecutive non-rejectable cores in all mix characteristics are found. Once this criteria is met, testing of any remaining cores is terminated. A minimum of three cores will require testing with the first one counting in both directions.

The contractor is required to cut the cores at his expense, however, if no rejectable material is found, he is compensated at the rate of $30.00 per core.

The limits of rejectable material are halfway between the first non-rejectable core and the last rejectable core in each direction. In Figure 1, two examples are presented; the first showing a rejectable area and the second where no rejectable material was identified. In each example, testing started at core #3 (closest to the rejectable plate sample) and progressed outward in each direction until two non-rejectable results were obtained. Testing of cores was then terminated. In example 2, the Ministry would accept the lot with no penalty to the contractor and he would be paid $30.00 for each core cut.

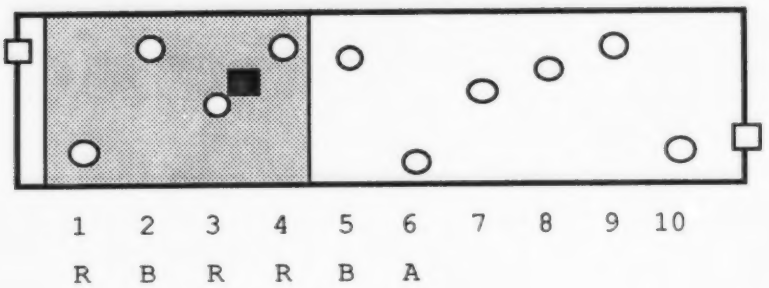
The Ontario road-builders, in discussions with the Ministry, requested that three cores be cut within a metre radius of a rejectable plate sample to verify the results prior to an extensive coring programme to define limits. The Ministry argued that the existing system accomplished both objectives in a more timely fashion. Furthermore, the Ministry had no experience in what to expect of test results from samples taken in such close proximity. The Ministry did however agree to simulate the suggested procedure on a limited number of contracts.

TABLE 1: ACCEPTANCE CRITERIA

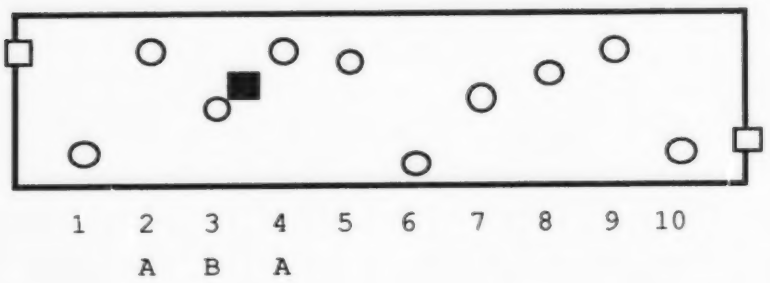
Material	Characteristics	Acceptable Zone %	Borderline Zone %	Rejectable Zone %
Surface Course Mixes	+4.75 mm	±5.0	+5.1 to +7.5 -5.1 to -7.5	>+7.5 <-7.5
	-75µm	±2.0	+2.1 to +3.0 -2.1 to -3.0	>+3.0 <-3.0
Binder and Levelling Course Mixes	+4.75 mm	±7.0	+7.1 to +10.0 -7.1 to -10.0	>+10.0 <-10.0
	-75µm	±2.0	+2.1 to +3.0 -2.1 to -3.0	>+3.0 <-3.0
All Mixes	Asphalt Content	±0.30	+0.31 to +0.50 -0.31 to -0.50	>+.50 <-.50

FIGURE 1: EXAMPLES, CORING PROGRAMME ACCEPTANCE/REJECTION

Example 1



Example 2



LEGEND

A = Acceptable

B = Borderline

R = Rejectable

Non-rejectable Plate Sample

Rejectable Plate Sample

Core

Rejectable Area

SAMPLING AND TESTING

One contract in each of the Ministry's five regions was selected to conduct the simulation. On each contract, three 150 mm cores were cut from binder course pavement at a 1 m radius of ten consecutive plate samples . The testing of the plate and core samples was conducted by the same technician in the same laboratory . The perimeter of the core samples were trimmed to eliminate cut faces. All samples were tested for asphalt cement content and for gradation of the extracted aggregates.

TEST RESULTS

The mean asphalt cement, retained 4.75 mm and 75 µm content, as determined from the plate samples (n=10) and the core samples (n=30) were found to be in very close agreement. The standard deviation of the core results is slightly lower than the plate samples in three of the five contracts for both the asphalt cement and + 4.75 mm content. Table 2 presents a five contract summary of the mean and standard deviation values for asphalt and + 4.75 mm content. The variation in 75 µm content is very low and is not presented.

TABLE 2: FIVE CONTRACT SUMMARY

	ASPHALT CEMENT (%)		+ 4.75 mm (%)	
CONT.	PLATES MEAN/ST.DEV.	CORES MEAN/ST.DEV.	PLATES MEAN/ST.DEV.	CORES MEAN/ST.DEV.
A	5.5 / 0.27	5.5 / 0.19	46.6 / 1.89	45.5 / 1.76
B	4.8 / 0.16	4.9 / 0.19	44.8 / 4.08	45.7 / 2.64
C	5.6 / 0.31	5.6 / 0.26	43.3 / 3.25	43.7 / 2.06
D	4.6 / 0.15	4.7 / 0.21	42.3 / 2.25	41.0 / 3.47
E	5.5 / 0.28	5.5 / 0.22	40.2 / 2.57	39.7 / 2.61

Although the mean values are in close agreement, individual core results do differ significantly from the adjacent plate sample. (Summaries of individual results for each of the five contracts are presented in the appendix.) However, 88% of the three-core averages supported the plate acceptable / borderline / rejectable determinations for asphalt cement, + 4.75 mm and + 75 µm content.

It seems reasonable to expect the three-core values to be distributed on either side of the corresponding plate value, but in fact, in 50 % of the cases the core values all fell on one side of the plate value for either asphalt content or + 4.75 mm content. On contract "C" all samples 5 through 9 have the core values to one side of the plate value for both asphalt and + 4.75 mm content. In this case, it appears that the technician segregated the test portion of the plate sample for when the + 4.75 mm content goes up the corresponding asphalt content goes down. See the control charts for each contract on subsequent pages.

Below the control charts on each page, scatter charts with the asphalt cement content plotted against the + 4.75 mm content are presented for both the plate and core samples. On these charts the mix design target is plotted along with the best fit line and the correlation coefficient (R). When looking at these charts one must keep in mind that for each plate data point there are three core data points. The pattern of the scatter for both the plate and core samples is similar on each contract indicating both methods of sampling represent the population. On four contracts the data points are grouped around the target but on contract "D" the mix is completely off target with both low asphalt and stone content.

On contracts "A" and "B" the scatter is random, indicating no particular relationship between asphalt and stone content. The data points on contract "C" indicate a slight relationship between the two variables and the data points on contracts "D" and "E" show a strong relationship. This strong relationship in both the plate and core samples suggests that the mix is segregated. Had the trend only shown in the plate samples and not the cores,(as on contract "C") it would be reasonable to assume the technician had segregated the sample portion by mixing and quartering.

With the exception of contract "D", which is off target, the best fit line comes close to the mix design target (+) whether or not segregation is present. This indicates that on average, the desired mix, or close to it, is being produced. Individual plate sample test results do vary widely but when averaged in lots of four the variance is greatly diminished and more closely represents the mix as produced. An example of this is presented in table 3 with the asphalt cement content, as determined from plate samples, shown both as single test variance and the variance of a four test average. This averaging causes all the asphalt content determinations for the five contracts to fall in the acceptable zone whereas 15 fell in the borderline zone based on single tests. Similar results are attained for + 4.75 mm and + 75 µm content.

TABLE 3: VARIANCE OF ASPHALT CONTENT DETERMINATIONS

CONTRACT	ASPHALT CONTENT VARIANCE (%) SINGLE TEST (n = 10)	AVERAGE OF 4 (n = 2)
A	0.79	0.04
B	0.44	0.02
C	0.94	0.01
D	0.38	0.07
E	0.88	0.05

DISCUSSION

In other work, where the Ministry has tested replicate samples in a second laboratory, little correlation of single test results was found, even though similar means and standard deviation were achieved. Given this, one should not expect any better results from different samples taken in close proximity.

ASTM, in the precision and bias statement for D 2172 "Standard Test Methods for Quantitative Extraction of Bitumen From Paving Mixtures", states in part:--"results from two properly conducted tests by the same operator on the same batch should not differ by more than 0.52%." The asphalt content determinations, plate/core or core/core in this study rarely exceeded this tolerance even though they represent different samples.

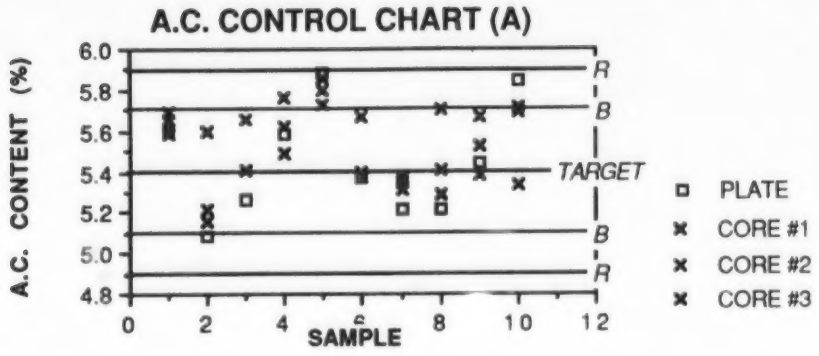
STUDY RESULTS

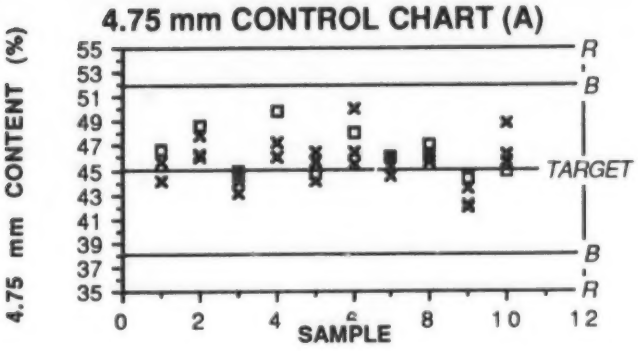
Based on this study the Ministry decided to continue with the existing procedure of extracting ten cores from a suspect area.

However, this work has demonstrated the need for acceptance to be based on the results of more than a single test.

As a result, the Ministry with the support of the Ontario Road Builders Association, has speeded up it's timetable for the implementation of end-result-specifications. The proposed acceptance scheme will base acceptance on the average of four tests within a lot of approximately 2000 t with limits on the range between test results within a lot.

This scheme will be tested using acceptance test data from current 1988 construction and revised if necessary prior to implementation.


A.C. CONTROL CHART (A)
A.C. CONTENT (%)
6.0
5.8
5.6
5.4
5.2
5.0
4.8
R
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE
PLATE
CORE #1
CORE #2
CORE #3


4.75 mm CONTROL CHART (A)
4.75 mm CONTENT (%)
55
53
51
49
47
45
43
41
39
37
35
R
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE

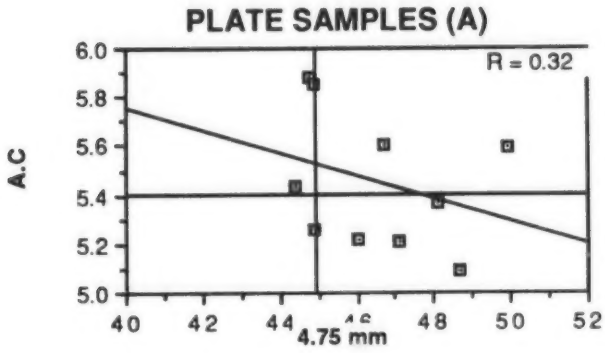
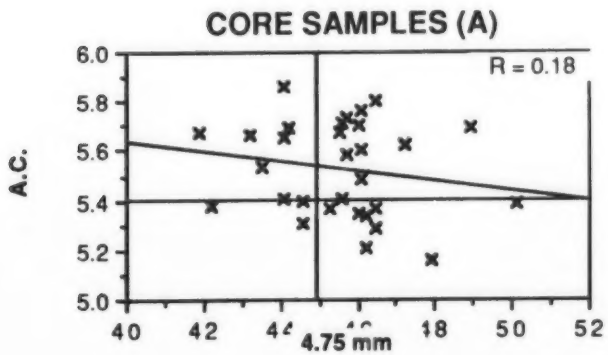
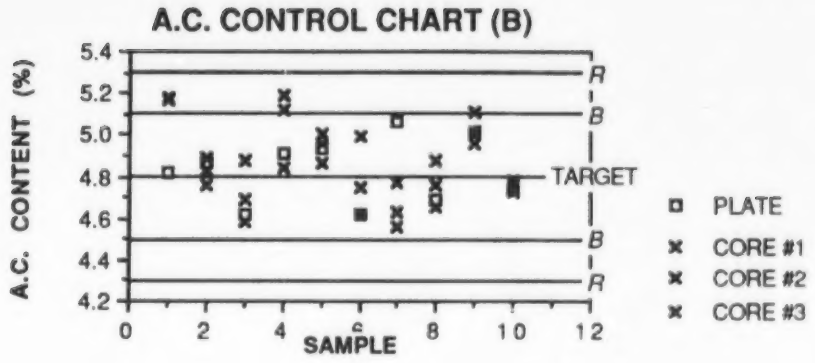
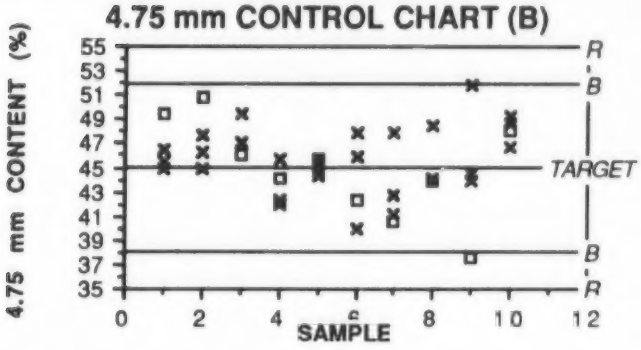


PLATE SAMPLES (A)
A.C
6.0
5.8
5.6
5.4
5.2
5.0
R = 0.32
40
42
44
48
50
52
4.75 mm


CORE SAMPLES (A)
A.C.
6.0
5.8
5.6
5.4
5.2
5.0
R = 0.18
40
42
50
52
4.75 mm


A.C. CONTROL CHART (B)
A.C. CONTENT (%)
5.4
5.2
5.0
4.8
4.6
4.4
4.2
R
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE
PLATE
CORE #1
CORE #2
CORE #3


4.75 mm CONTROL CHART (B)
4.75 mm CONTENT (%)
55
53
51
49
47
45
43
41
39
37
35
R
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE

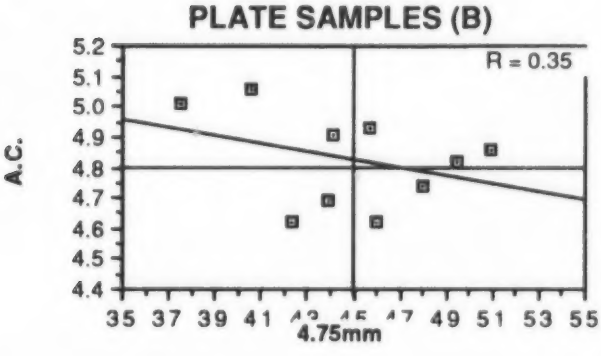
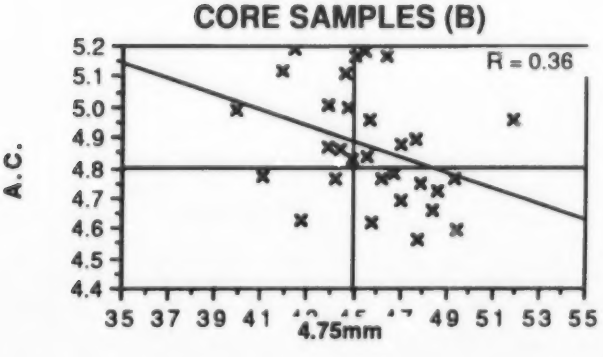
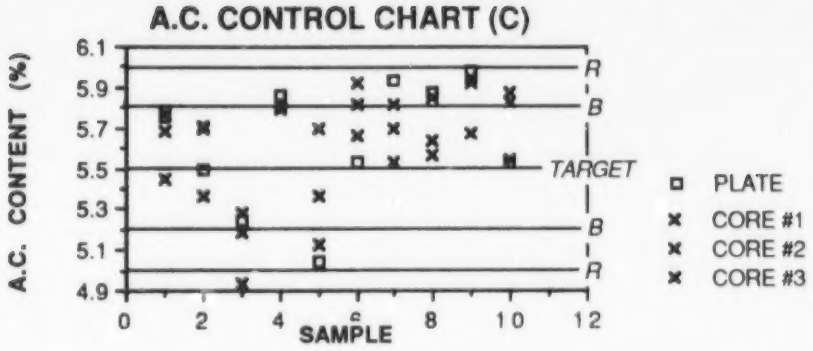
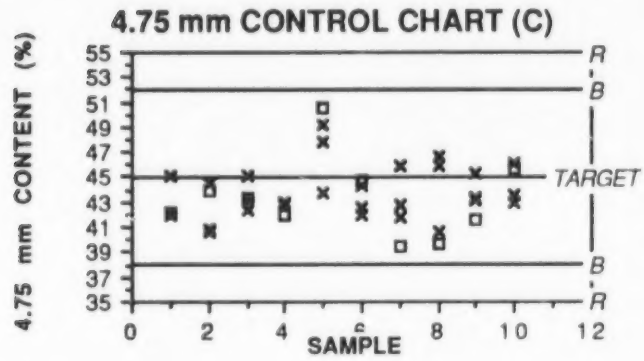


PLATE SAMPLES (B)
A.C.
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
R = 0.35
35 37 39 41 43 45 47 49 51 53 55
4.75mm


CORE SAMPLES (B)
A.C.
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
R = 0.36
35 37 39 41 43 45 47 49 51 53 55
4.75mm


A.C. CONTROL CHART (C)
A.C. CONTENT (%)
6.1
5.9
5.7
5.5
5.3
5.1
4.9
R
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE
PLATE
CORE #1
CORE #2
CORE #3


4.75 mm CONTROL CHART (C)
4.75 mm CONTENT (%)
55
53
51
49
47
45
43
41
39
37
35
R
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE

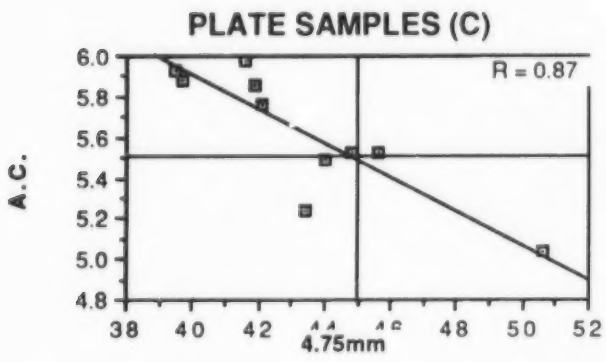
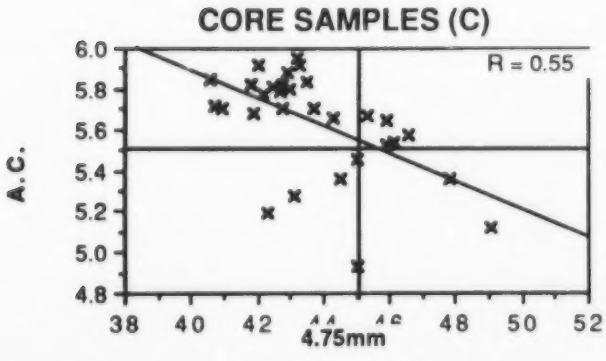
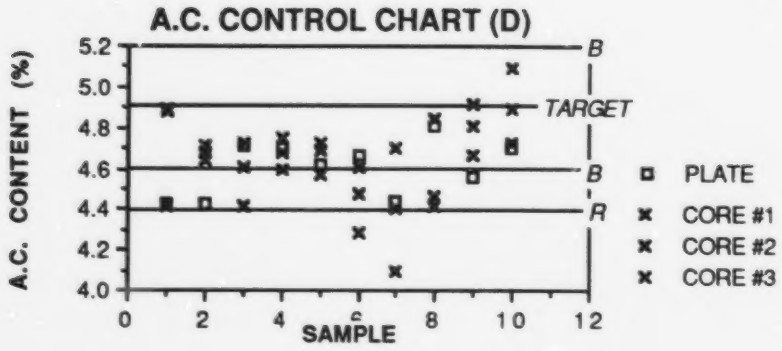
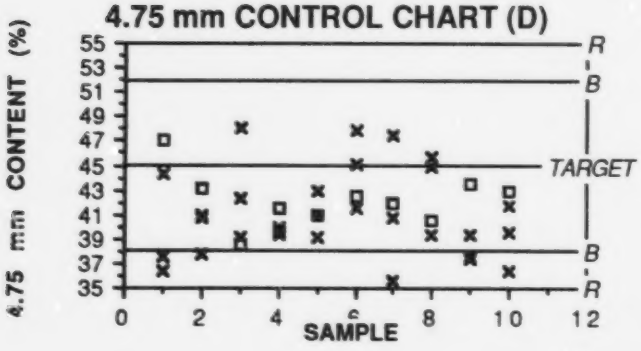


PLATE SAMPLES (C)
A.C.
6.0
5.8
5.6
5.4
5.2
5.0
4.8
R = 0.87
38
40
42
44
46
48
50
52
4.75mm


CORE SAMPLES (C)
A.C.
6.0
5.8
5.6
5.4
5.2
5.0
4.8
R = 0.55
38
40
42
44
46
48
50
52
4.75mm


A.C. CONTROL CHART (D)
A.C. CONTENT (%)
5.2
5.0
4.8
4.6
4.4
4.2
4.0
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE
PLATE
CORE #1
CORE #2
CORE #3


4.75 mm CONTROL CHART (D)
4.75 mm CONTENT (%)
55
53
51
49
47
45
43
41
39
37
35
R
B
TARGET
B
R
0
2
4
6
8
10
12
SAMPLE

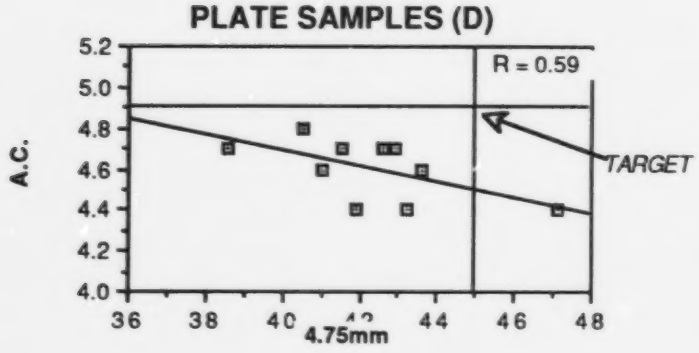
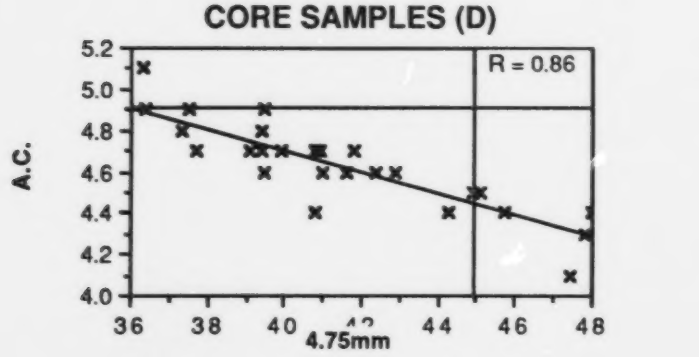
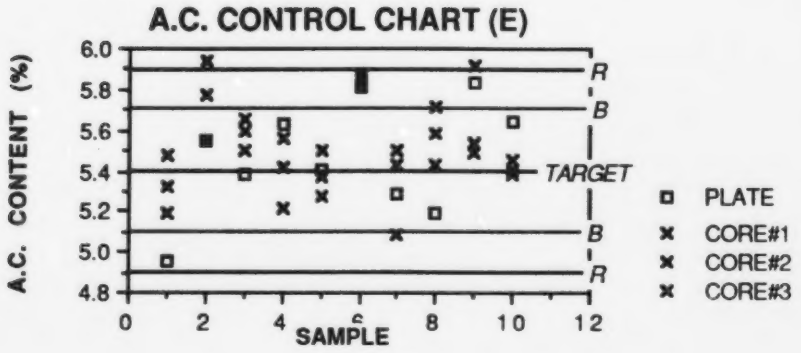
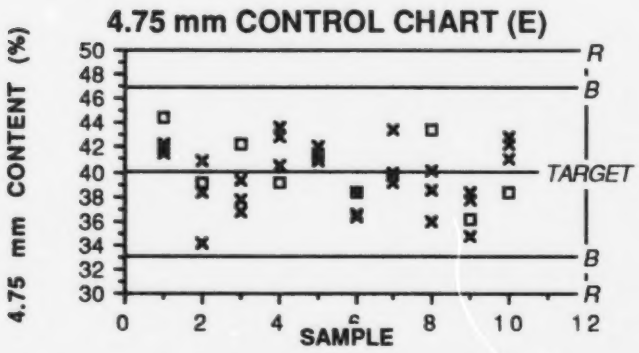


PLATE SAMPLES (D)
A.C.
5.2
5.0
4.8
4.6
4.4
4.2
4.0
R = 0.59
TARGET
36
38
40
44
46
48
4.75mm


CORE SAMPLES (D)
A.C.
5.2
5.0
4.8
4.6
4.4
4.2
4.0
R = 0.86
36
38
40
44
46
48
4.75mm


A.C. CONTROL CHART (E)
A.C. CONTENT (%)
6.0
5.8
5.6
5.4
5.2
5.0
4.8
R
B
TARGET
B
R
0
2
4
8
10
12
SAMPLE
PLATE
CORE#1
CORE#2
CORE#3


4.75 mm CONTROL CHART (E)
4.75 mm CONTENT (%)
50
48
46
44
42
40
38
36
34
32
30
R
B
TARGET
B
R
0
2
4
8
10
12
SAMPLE

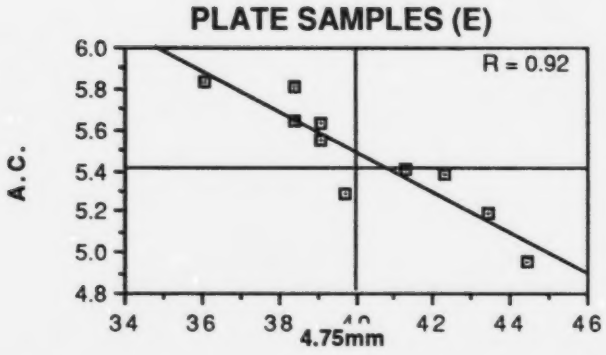
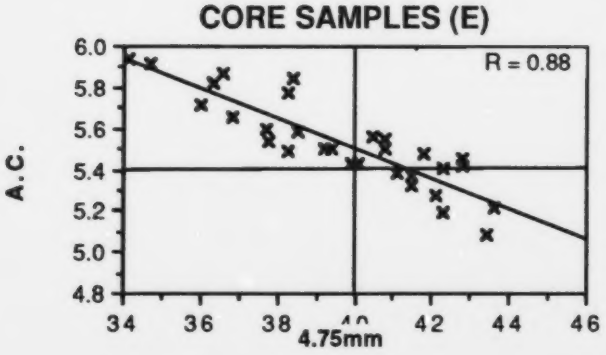


PLATE SAMPLES (E)
A.C.
6.0
5.8
5.6
5.4
5.2
5.0
4.8
R = 0.92
34
36
38
42
44
46
4.75mm


CORE SAMPLES (E)
A.C.
6.0
5.8
5.6
5.4
5.2
5.0
4.8
R = 0.88
34
36
38
42
44
46
4.75mm

APPENDIX 1-1

CONT. "A" HL-4 BINDER

LOT #	CRITERIA	DESIGN	PLATE	CORE 1	CORE 2	CORE 3	AVE. 1,2,3
	A.C.	5.40	5.60	5.69	5.58	5.65	5.64
5	4.75 mm	45.0	46.7	44.2	45.7	44.1	44.7
	75 µm	97.5	97.4	96.3	96.3	96.6	96.4
	A.C.	5.40	5.09	5.16	5.60	5.21	5.32
8	4.75 mm	45.0	48.7	47.9	46.1	46.2	46.7
	75 µm	97.5	96.4	96.3	96.5	96.1	96.3
	A.C.	5.40	5.26	5.66	5.40	5.41	5.49
10	4.75 mm	45.0	44.9	43.2	44.6	44.1	44.0
	75 µm	97.5	97.3	96.4	96.5	96.5	96.5
	A.C.	5.40	5.59	5.49	5.76	5.62	5.62
11	4.75 mm	45.0	49.9	46.1	46.1	47.2	46.5
	75 µm	97.5	96.7	95.8	95.9	95.8	95.8
	A.C.	5.40	5.88	5.80	5.73	5.86	5.80
12	4.75 mm	45.0	44.8	46.5	45.7	44.1	45.4
	75 µm	97.5	97.0	96.9	96.9	96.0	96.6
	A.C.	5.40	5.37	5.67	5.37	5.39	5.48
13	4.75 mm	45.0	48.1	45.5	46.5	50.1	47.4
	75 µm	97.5	96.0	96.4	95.9	96.5	96.3
	A.C.	5.40	5.22	5.31	5.37	5.35	5.34
14	4.75 mm	45.0	46.0	44.6	45.3	46.0	45.3
	75 µm	97.5	96.3	96.8	96.5	96.3	96.5
	A.C.	5.40	5.21	5.29	5.41	5.70	5.47
15	4.75 mm	45.0	47.1	46.5	45.6	46.0	46.0
	75 µm	97.5	96.1	96.2	96.2	96.5	96.3
	A.C.	5.40	5.44	5.38	5.53	5.67	5.53
16	4.75 mm	45.0	44.4	42.2	43.5	41.9	42.5
	75 µm	97.5	96.5	96.6	95.8	96.3	96.2
	A.C.	5.40	5.85	5.69	5.71	5.34	5.58
17	4.75 mm	45.0	44.9	48.9	45.6	46.2	46.9
	75 µm	97.5	96.4	96.7	96.4	96.8	96.6

APPENDIX 1-2

CONT. "B" RHM BINDER

LOT #	CRITERIA	DESIGN	PLATE	CORE 1	CORE 2	CORE 3	AVE. 1,2,3
57	A.C.	4.80	4.82	5.18	5.17	5.17	5.17
	4.75 mm	45.0	49.4	45.5	46.4	45.0	45.6
	75 µm	96.5	96.0	96.0	95.7	95.6	95.8
58	A.C.	4.80	4.86	4.89	4.83	4.76	4.83
	4.75 mm	45.0	50.9	47.7	44.9	46.2	46.3
	75 µm	96.5	96.4	96.1	95.8	95.9	95.9
59	A.C.	4.80	4.62	4.88	4.69	4.59	4.72
	4.75 mm	45.0	46.0	47.0	47.0	49.4	47.8
	75 µm	96.5	96.1	96.1	95.9	96.1	96.0
60	A.C.	4.80	4.91	4.84	5.12	5.19	5.05
	4.75 mm	45.0	44.1	45.6	41.9	42.4	43.3
	75 µm	96.5	96.0	96.0	96.0	96.0	96.0
61	A.C.	4.80	4.93	4.96	4.86	5.00	4.94
	4.75 mm	45.0	45.7	45.7	44.4	44.7	44.9
	75 µm	96.5	96.2	96.2	96.0	95.8	96.0
62	A.C.	4.80	4.62	4.75	4.99	4.62	4.79
	4.75 mm	45.0	42.3	47.9	39.9	45.8	44.5
	75 µm	96.5	96.7	96.1	95.6	96.2	96.0
63	A.C.	4.80	5.06	4.77	4.63	4.56	4.65
	4.75 mm	45.0	40.5	41.1	42.7	47.8	43.9
	75 µm	96.5	96.5	95.4	96.1	95.9	95.8
64	A.C.	4.80	4.69	4.87	4.66	4.76	4.76
	4.75 mm	45.0	43.9	43.9	48.4	44.2	45.5
	75 µm	96.5	95.9	95.9	96.2	96.9	96.3
65	A.C.	4.80	5.01	5.01	4.96	5.11	5.03
	4.75 mm	45.0	37.5	43.9	51.9	44.6	46.8
	75 µm	96.5	95.5	96.2	96.6	96.2	96.3
66	A.C.	4.80	4.74	4.72	4.78	4.76	4.75
	4.75 mm	45.0	48.0	48.6	46.7	49.3	48.2
	75 µm	96.5	96.1	96.7	96.4	96.4	96.5

APPENDIX 1-3

CONT. "C" HL-4 BINDER

LOT #	CRITERIA	DESIGN	PLATE	CORE 1	CORE 2	CORE 3	AVE. 1,2,3
	A.C.	5.50	5.76	5.77	5.45	5.68	5.63
1	4.75 mm	45.0	42.1	42.2	45.0	41.9	43.0
	75 µm	96.7	96.6	96.6	96.6	96.6	96.6
	A.C.	5.50	5.49	5.71	5.36	5.70	5.59
2	4.75 mm	45.0	44.0	40.7	44.5	40.9	42.0
	75 µm	96.7	96.5	96.6	96.6	96.5	96.6
	A.C.	5.50	5.24	5.19	4.93	5.28	5.13
3	4.75 mm	45.0	43.4	42.3	45.0	43.1	43.5
	75 µm	96.7	96.7	96.7	96.8	96.6	96.7
	A.C.	5.50	5.86	5.79	5.82	5.80	5.80
4	4.75 mm	45.0	41.9	42.7	42.8	43.0	42.8
	75 µm	96.7	96.5	96.7	96.7	96.6	96.7
	A.C.	5.50	5.04	5.36	5.12	5.70	5.39
5	4.75 mm	45.0	50.6	47.8	49.1	43.7	46.9
	75 µm	96.7	97.1	96.9	96.9	96.6	96.8
	A.C.	5.50	5.53	5.81	5.92	5.66	5.80
6	4.75 mm	45.0	44.8	42.5	42.0	44.3	42.9
	75 µm	96.7	96.8	96.7	96.7	96.8	96.7
	A.C.	5.50	5.93	5.70	5.53	5.82	5.68
7	4.75 mm	45.0	39.5	42.8	45.9	41.8	43.5
	75 µm	96.7	96.6	96.7	96.8	96.6	96.7
	A.C.	5.50	5.88	5.85	5.64	5.57	5.69
8	4.75 mm	45.0	39.7	40.6	45.9	46.6	44.4
	75 µm	96.7	96.5	97.0	96.8	96.8	96.9
	A.C.	5.50	5.98	5.95	5.67	5.92	5.85
9	4.75 mm	45.0	41.6	43.2	45.3	43.3	43.9
	75 µm	96.7	96.8	96.8	96.7	96.8	96.8
	A.C.	5.50	5.53	5.54	5.83	5.88	5.60
11	4.75 mm	45.0	45.6	46.1	43.5	42.9	44.2
	75 µm	96.7	97.0	96.7	96.8	96.7	96.7

APPENDIX 1-4

CONTRACT "D" RHM BINDER

LOT #	CRITERIA	DESIGN	PLATE	CORE 1	CORE 2	CORE 3	AVE. 1,2,3
84	A.C.	4.90	4.43	4.42	4.89	4.88	4.73
	4.75 mm	45.0	47.1	44.3	37.5	36.4	39.4
	75 µm	97.6	97.0	96.6	96.4	96.4	96.5
85	A.C.	4.90	4.43	4.64	4.68	4.71	4.68
	4.75 mm	45.0	43.2	41.0	40.8	37.7	39.8
	75 µm	97.6	96.9	96.7	96.7	96.6	96.7
86	A.C.	4.90	4.71	4.72	4.61	4.41	4.58
	4.75 mm	45.0	38.6	39.1	42.4	48.0	43.2
	75 µm	97.6	96.7	96.6	96.7	96.9	96.7
87	A.C.	4.90	4.70	4.68	4.75	4.60	4.68
	4.75 mm	45.0	41.5	39.9	39.4	39.5	39.6
	75 µm	97.6	96.9	96.5	96.6	96.9	96.7
88	A.C.	4.90	4.62	4.72	4.57	4.69	4.66
	4.75 mm	45.0	41.0	39.1	42.9	40.9	41.0
	75 µm	97.6	96.7	96.5	96.8	96.6	96.6
89	A.C.	4.90	4.66	4.47	4.29	4.61	4.46
	4.75 mm	45.0	42.6	45.1	47.8	41.6	44.8
	75 µm	97.6	96.7	96.7	96.8	96.7	96.7
90	A.C.	4.90	4.44	4.70	4.09	4.40	4.40
	4.75 mm	45.0	41.9	35.6	47.4	40.8	41.3
	75 µm	97.6	96.9	96.6	96.9	96.7	96.7
91	A.C.	4.90	4.81	4.84	4.42	4.46	4.57
	4.75 mm	45.0	40.5	39.4	45.7	44.9	43.3
	75 µm	97.6	96.7	96.4	96.7	96.6	96.6
92	A.C.	4.90	4.56	4.91	4.67	4.81	4.80
	4.75 mm	45.0	43.6	37.5	39.4	37.3	38.1
	75 µm	97.6	96.8	96.3	96.4	96.4	96.4
93	A.C.	4.90	4.70	4.73	5.09	4.89	4.90
	4.75 mm	45.0	42.9	41.8	36.3	39.5	39.2
	75 µm	97.6	96.8	96.6	96.4	96.6	96.5

APPENDIX 1-5

CONT. "E" RHM BINDER

LOT #	CRITERIA	DESIGN	PLATE	CORE 1	CORE 2	CORE 3	AVE. 1,2,3
12	A.C.	5.40	4.95	5.19	5.32	5.48	5.33
	4.75 mm	40.0	44.4	42.3	41.5	41.8	41.9
	75 µm	95.5	94.9	94.6	94.7	94.7	94.7
13	A.C.	5.40	5.55	5.55	5.94	5.78	5.76
	4.75 mm	40.0	39.1	40.8	34.1	38.3	37.7
	75 µm	95.5	94.9	94.8	94.3	94.6	94.6
14	A.C.	5.40	5.38	5.60	5.50	5.66	5.59
	4.75 mm	40.0	42.3	37.7	39.4	36.8	38.0
	75 µm	95.5	94.8	94.1	94.3	94.2	94.2
15	A.C.	5.40	5.63	5.56	5.21	5.42	5.40
	4.75 mm	40.0	39.1	40.5	43.6	42.8	42.3
	75 µm	95.5	95.1	94.8	95.1	95.0	95.0
16	A.C.	5.40	5.40	5.28	5.50	5.37	5.38
	4.75 mm	40.0	41.3	42.1	40.8	41.5	41.5
	75 µm	95.5	94.8	94.5	94.4	94.5	94.5
17	A.C.	5.40	5.81	5.84	5.87	5.82	5.84
	4.75 mm	40.0	38.4	38.4	36.6	36.3	37.1
	75 µm	95.5	94.4	94.4	94.1	94.0	94.2
18	A.C.	5.40	5.29	5.08	5.43	5.50	5.34
	4.75 mm	40.0	39.7	43.4	39.9	39.2	40.8
	75 µm	95.5	94.2	94.5	94.6	94.2	94.4
19	A.C.	5.40	5.19	5.43	5.58	5.71	5.57
	4.75 mm	40.0	43.4	40.1	38.5	36.0	38.2
	75 µm	95.5	95.0	94.3	94.4	94.2	94.3
20	A.C.	5.40	5.83	5.49	5.92	5.54	5.65
	4.75 mm	40.0	36.1	38.3	34.7	37.8	36.9
	75 µm	95.5	94.6	94.3	94.0	94.2	94.2
21	A.C.	5.40	5.64	5.45	5.38	5.41	5.41
	4.75 mm	40.0	38.4	42.8	41.1	42.3	42.1
	75 µm	95.5	94.5	94.4	94.3	94.5	94.4